SCIENCE

VOL. 77 FRIDAY, JUNE 23, 1933 No. 2008

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SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal

Lancaster, Pa. Garrison, N. Y.

Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

ELECTRICITY RELEASED FROM MATTER[1]

By Dr. KARL K. DARROW

BELL TELEPHONE LABORATORIES, NEW YORK, N. Y.

IN this situation I am reminded of something written a few years ago by Dr. Keen, the noted surgeon of Philadelphia. Dr. Keen was born in 1837 and he remembers men who were in their eighties when he was a child. Those men were born about 1760, and they in turn remembered men who were born around 1700 and whose lives therefore overlapped the life of Isaac Newton. So short is the history of physical science that three human lives suffice to span the entire time from our days back to the founder of modern physics! This is an extraordinary fact to think of, and no less extraordinary is the fact that *two* human lives suffice to cover almost the whole of the history of electrical science. One of these is the lifetime of our distinguished guest.

[1] Address delivered at the Massachusetts Institute of Technology, March 29, 1933, in connection with the celebration of Professor Elihu Thomson's eightieth birthday.

Try to think back, not 80 but 160 years, to the year 1773. Then, there was hardly anything deserving the name of electrical science—little more than an orderless assortment of quaint scraps of information about static charges, sparks and permanent magnets. Only one great electrician whose name we all remember lived wholly before that time; he was, of course, Gilbert. One other did most of his electrical work before that year, though he lived long past it; that, of course, was Benjamin Franklin. Now try to recall all the names of early electricians you possibly can. Unless you have lately been reading the history of electricity, I would wager that every one of them will belong to the 80 years following 1853. You will doubtless begin by running over the names of the electrical units. Well, Volta, Coulomb, Ampere, Gauss, Weber, Faraday and Henry all flourished in that period; and so did Galvani, Oersted, Cavendish and Davy.

These were the men who organized the science of electricity. They discovered the laws of attraction and repulsion of charged pithballs; the laws of attraction and repulsion of current-carrying wires; the laws of electrolysis. Above all, they achieved the synthesis of electricity and magnetism. Their work was so thorough and their results so extensive that one is amazed to-day to realize that they never had a chance of studying electricity outside of dense matter. Electricity to them was a mysterious and reticent entity which normally lurked in the depths of liquids and solids. It never seemed to want to come out into the open, and if it was forced into the open by the processes of thunderstorms or static machines, it hastened straight back into shelter with the utmost speed and violence.

Imagine a physicist who wants to study the nature and properties of water, but never has any at his disposal, except in damp sponges, moistened blotting-paper and crystals containing water of crystallization. Suppose him forbidden to squeeze the water out of the sponges, or steam it out of the blotting-paper, or distil it out of the crystals. This unfortunate person would be in somewhat the same position as the electrician of a century ago, except with regard to the spark. To find an image for the spark, we must concede him one more privilege: we must allow him to pump water out of a hidden reservoir through a pipe into a tank. He would like to be able to draw it off from the tank through a spigot in a small slow stream which he can easily observe and use. But, owing to some strange handicap, he can not do this; he can only pump water steadily into the tank until finally it gives way and bursts wide open and all the accumulated liquid rushes out in one terrific torrent, flooding all the neighborhood and threatening to drown the observer.

As usual, the simile is imperfect and has to be amended. We must suppose that the wall of the tank heals itself as soon as all the water has rushed out, and remains impervious until the internal pressure has mounted up again to a great height. Evidently what our physicist needs (since he can not have a spigot) is a tank which will crack open when there is only a little water in it, so that the outflow will be slow, and preferably just as slow as the influx of new water from the hidden reservoir which the pump is sending up. Now in my parable the tank is one of two metal electrodes which are connected to opposite poles of a battery. If the electrodes are separated by air of normal atmospheric density, the charge on the negative electrode can not burst out until it is built up to a hugely excessive amount. Then the wall of the metal is breached and the charge pours out with great violence until it is nearly all gone, after which the wall is closed and no more charge escapes until a new great excess is crowded into the electrode.

What can be done to persuade the charge to come out earlier? to come out gently and gradually and slowly, so that the flow can be steady, and easy to observe and to control? The answers to this question form all together one of the greatest achievements of the 80 years just past. I will recall them briefly to you.

The first answer was: form an arc in the open air between carbon or metal pole-pieces. This was given by Davy about 1815. It is not a convenient solution for one who wants to study electricity released from matter, because the electrical particles get badly tangled up with the molecules of the air almost as soon as they escape from the negative electrode.

The next answer was: put the electrodes into a tube and pump out the air until what is left has only about a thousandth of the normal atmospheric density. This is an admirable solution. Faraday made a good beginning, but for some reason or other relinquished this field of research. It was not properly developed until the eighteen-sixties and the eighteen-seventies. We ought first to remember the name of the man who made the tubes, for in 1860 the injunction "seal the electrodes into a tube" was not so easy to obey as now. This man was an itinerant glass-blower who earned his living by wandering from college to college in Germany and blowing such glassware as the professors of chemistry and physics might happen to want; his name was Geissler. In Bonn he found a professor who wanted low-pressure discharge-tubes for spectroscopic purposes, as the science of spectroscopy was then just coming into being. Reserving the spectra for himself, this professor turned over the task of studying the electrical properties of the discharge to one of his pupils. This pupil, whose name was Hittorf, obtained the chair of chemistry and physics in a small and half-starved college, where he stayed for fifty years. In 1869 he published the first of his great papers; I will quote its opening sentence: "The darkest part of the science of electricity to-day is incontrovertibly the process by which current is conducted through gases." Nowadays we should say just the opposite, and for that we should thank Hittorf; and also Crookes, and others after them, but Hittorf first of all.

When the density of the gas in the tube is about a thousandth of atmospheric density, there is a very striking and lovely pattern of colored lights and shades, luminous clouds and intervening gulfs of darkness; but these are signs that the electrical particles are getting tangled up with molecules of the gas, as in the arc. When the density is ten or a hundred times lower, they disappear and opposite the cathode one may see a green fluorescence spread over

the glass wall of the tube. This is due to electrical rays proceeding from the cathode. They travel in straight lines perpendicularly outward from the cathode surface, for if a metal emblem is put in front of the cathode one sees its shadow black and sharply bounded upon the green expanse. If the cathode is bowl-shaped they are focused at the center of curvature of the bowl, and here they will melt even a metal like platinum, which proves that they carry energy with them. If a negatively charged object is brought up close to the tube (with certain precautions) the green flare moves off, showing that the rays are pushed away by the negative charge. If a magnet is brought up, the rays are shifted as a wire would be if it were carrying negative charge straight outward from the cathode.

These cathode rays are therefore a stream of negative charges, pouring out of the cathode and acquiring such energy and such momentum that they hammer themselves against the opposite wall of the tube. So rarefied is the gas that many of them go clear to the opposite wall unimpeded and unintercepted. It is because of the haste of their flight and the tenuity of the gas that they are able to move in straight lines across the hollow of the tube, and reveal themselves by making the glass of the wall fluoresce, and respond to magnets and to distant charges in ways which make their nature manifest. It is because of the haste of their flight and the tenuity of the gas that they remain what they are when they quit the metal: free negative electricity, released from dense matter, disconnected from atoms, unburdened and discarnate.

Rarefied as the gas may be in these experiments, it is actually responsible for the escape of electricity from the cathode. To use my former metaphor, it is the gas which breaks down the wall confining the electrical corpuscles inside the metal. It is preferable, however, to change the metaphor and to say that the gas helps the electricity over the wall. It does this best when its density is neither too high nor too low; at atmospheric density we get only the violent sparks, at very low density, nothing at all. Why this should be so, and how the gas achieves the feat of helping the electricity out of the metal, are very intricate questions to which the answers are only just beginning to be clear. Fortunately it happens that there are two ways of persuading electricity to come out of a metal, which involve no gas at all and are easy to understand. Both of these were discovered in the eighties. You know the agents involved; they are heat and light.

As for the efficacy of heat: various early savants observed phenomena which we with our riper knowledge can explain by it, but there is strong reason for giving the honor of discovery to a man who, as chairmen say, "needs no introduction"—Edison. He in 1884 was working with his carbon-filament lamps, these pre-war "incandescent lights" which nowadays, I suppose, must look as quaintly old-fashioned to people in their twenties as a kerosene lamp to people in their forties. The filament of carbon, enclosed in a pear-shaped bulb evacuated to the degree then called "high vacuum," rose in a single fragile arch from its leads in the socket, and the current was meant to flow the entire length of the arch. Edison, however, noticed that a good share of the current was evading its duty, leaking out of the negative end of the arch and sneaking across the hollow of the tube to the positive end. This he proved by making lamps with an extra lead, connected inwardly to a metal plate projecting into the hollow space between the bases of the arch, outwardly through an ammeter to the positive filament lead; there was a flow of current through the ammeter.

This was one of the great observations of history. On its result repose essential portions of the art and science of telephony over long distances, whether by wire or wireless; broadcasting; many devices for remote control; a thousand ingenious feats of engineering, ten thousand delicate aids to detection of light and sound and electricity, to measurement and research. In the electric lamp a mere annoyance, this "thermionic effect" is the vital principle of those other dimmer lamps not meant for lighting, the tubes of the radio sets now almost as familiar as electric light itself.

At this point of the narration almost any layman would assume that Edison himself went onward and discovered all these things. Not so! this was one of the occasions when the race was not to the swift, nor the battle to the strong. The keen inventor thought so little of this thing which had lain across his path that he showed it to a traveling British electrical engineer named Preece, and not only showed it to him but made up some extra tubes for him to take home and study at his leisure. Preece and Fleming studied the effect with care; but, so foreign to the human mind was then the idea of free electricity, they could not shake off the idea that the carbon filament must be projecting its own substance forth into space, with negative charges clinging to the atoms. Crookes entertained the same idea about the cathode rays in his low-pressure discharge-tubes. There are animals which are obliged to live successive stages of their growth in different media, first water and then air. Somewhat the same destiny was imposed on the thermionic effect as a division of human knowledge; born in the workshop of an inventor, started in life by electrical engineers, it attained to maturity in the academic world.

J. J. Thomson fostered the study of the effect at the English Cambridge, but turned it over in the main

to his pupil, Richardson, as in an earlier generation Plücker had entrusted the low-pressure discharge to Hittorf. Richardson discovered the major laws of the effect and showed that they permit a beautifully lucid theory. We are to think of the metal as populated by a swarm of corpuscles of negative charge—henceforth I will no longer avoid the word "electrons"—which rush about in thermal agitation and beat in an incessant patter against the wall of the metal. This "wall" is a metaphor for the force of attraction whereby the positive charges moored to the atoms of metal pull back on the electrons which are trying to escape, and which is in fact confined to a thin region along the surface of the metal. Some of the electrons are moving rapidly enough to overcome this pull, and they climb over the wall; but at room temperature their number is imperceptibly small. As the metal is warmed up, its heat is shared by the electrons, and the fraction which is able to escape increases steadily. Eventually the outflow becomes a perceptible current which rises rapidly with further rise of temperature. Its law of increase is like that of the vapor pressure of a liquid or a solid, and thus we are justified in saying that electrons evaporate out of a metal.

To expel electrons from a metal by heating the entire bulk is an effective way, but in a sense it is crude; we lavish quantities of energy on the atoms of the metal in order that the particles of electricity also may receive some. It would be neater to impart the energy directly to the electrons without wasting any of it upon the atoms. A distant approximation to this ideal is attained by sending a beam of light against the metal. It consists of corpuscles of energy, the so-called "photons"; and every now and then one of these will dive through the surface and yield up its total energy to an electron. This is the so-called "photoelectric effect."

The energy of the photons is greater, the smaller the wave-length of the light, and is calculable from the wave-length. With light of the visible spectrum, what the electron receives is not sufficient to help it over the wall unless the metal is one of those which have walls abnormally low—the alkali metals and their alloys, and a few others. With light of the remote ultra-violet, the photons have energy enough to enable electrons to climb out of any metal whatever. The necessary energy, or (to preserve the metaphor) the height of the wall, can be determined by observing the wave-length of the light which is just able to release electrons from the metal; for the energy of the photons of this light is the same as the quantity in question and it is calculable from the wave-length. The height of the wall can also be estimated from the rate at which the thermionic current increases with rise of temperature. The estimates by the two methods agree very well and this contributes very much to our confidence in the theoretical picture. The establishment of this picture by the study of the photoelectric effect is largely due to a happy alliance of the insight of Einstein with the experimental skill of Richardson, K. T. Compton and Millikan.

Now a few words about the qualities of negative charge when it has been released from matter and is available to our experimental arts. You are of course aware that it consists of corpuscles, the electrons of which I have already spoken, of which the charge and mass are definite and known. The exact evaluation of this charge and this mass, e and m as they are familiarly called, has been a great experimental problem of the early twentieth century. To be precise, its period overlaps slightly with the nineteenth century (J. J. Thomson having made the earliest fairly good estimates, towards 1895), and also with the future, since measurements are still being made; but probably the first quarter of the twentieth century will always be remembered as the time of the achievement. Both e and m are very small by ordinary standards; upwards of 10^{19} electrons are required to make up the charge which passes per second through the filament of an incandescent lamp, and upwards of 10^{27} to make up the mass of a gram. The eighteenth-century savants who spoke of electricity as a "subtle fluid" were well inspired, in so far as they meant negative electricity; its particles are the most nimble, agile, penetrating and insinuating of all that are known, except perhaps the corpuscles of light, which belong to another category of existence altogether.

Electrons in their passage through vacuum are of course invisible; they are perceived only when their flight has come to an end, as, for instance, by striking upon a fluorescent screen or a photographic plate or entering a metallic collector. Unimpeded flight is like a dreamless sleep, perceived only because it was unperceived while it lasted, known only when it is over. Nevertheless we can trace the paths of electron-streams through vacua with confidence, by noting where they end. It is interesting also to know that the paths of electron-streams may be made visible by using a suitable small density of gas. Occasional corpuscles elicit flashes of light from atoms which they strike, and these mark out the path which the main body of unimpeded corpuscles is following, as the path of an army through a hostile country by night could be marked by the flashes of shots fired by natives on whom occasional troopers happened to stumble.

The most pleasing feature of these corpuscles is that, in large-scale electric and magnetic fields such as we can make in the laboratory, they behave just in the way they should in order to account for the fundamental laws of electricity in dense matter discovered in the eighty years preceding 1853. Electrons repel one another like negatively charged pith-

balls; electrons dashing past a magnet are displaced like a current-carrying wire. (Indeed it is only because of this that we are able to define and measure the charge and mass of an electron). Perhaps this sounds self-evident, hardly worth the verifying, let alone the saying. However, there is no law of nature to the effect that things which seem self-evident are necessarily found to be true. I will tell you of a case where something not self-evident occurred.

Suppose we send a beam of electrons against a crystal. The crystal is an assemblage of atoms regularly arranged. Each atom is a collection of electric particles roaming in vacant space. The sizes of these particles are so small compared with the spaces between them that each atom may be regarded for the present purpose as a narrow empty region where there is an electric field (and also a magnetic field) varying rapidly from point to point. The crystal is an assemblage of these narrow concentrated fields, tens of millions of them to the linear inch. We might say that it is a region of space occupied by a rhythmic pattern of field strengths. This is traversed by the electron-stream, which behaves in a most remarkable way, as Davisson and Germer found. It behaves as though it were attended by a train of waves, and the crystalline pattern seized upon these waves and guided them according to the well-known laws of wave motion, while the corpuscles trailed along after them.

This is a notion difficult to admit, for we are not accustomed to water-waves or sound-waves dragging massive bodies with them, although there is a striking analogy to be found in the phenomena of light. One immediately inquires whether the concept of the waves would serve in the cases of electron-streams traversing large-scale electric and magnetic fields, such as we know so well in the laboratory. So it does; the deflections of electron-streams in such fields as these can be explained by supposing that the fields act directly upon wave-trains, which accompany the corpuscles and steer them. In these cases by themselves the idea of waves would be superfluous, since we can explain the phenomena as well without them. But when electrons pass through crystals the waves are necessary to account for the phenomena, and this obliges us to imagine them always. It is by no means easy to adapt one's thought to the conception of corpuscles guided by waves, nor to the further and highly abstracted refinements which this notion has undergone in the last few years. But I came here with the intention of speaking to you not of the perplexities of theory, but of the clarities of experiment; and I must not continue to impair your memories of these.

THE ELECTRON THEORY OF METALLIC CONDUCTION[1]

By Professor J. C. SLATER
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ELECTROMAGNETIC theory may be broadly divided into two parts: the theory of electric and magnetic fields and the theory of the electrical structure of matter, of conductors, insulators, magnetic bodies, charges, currents. Both branches have undergone profound changes since the time of Maxwell. The electromagnetic field has been of interest particularly in cases of very rapid oscillations, the waves of light and x-rays. There, from the photoelectric effect and other similar phenomena, has arisen the idea that in some respects light seems to behave in a corpuscular way, its energy being concentrated in particles of energy or photons. The electromagnetic waves of Maxwell and Hertz have but a statistical connection with the motion of these photons. The discreteness of the photons is shown beautifully by such a device as a Geiger counter, which can be made to register each photon as it comes along. In weak radiation of high frequency, as x-rays or gamma rays, no one after seeing the experiment can doubt the corpuscular nature inherent somewhere in the phenomenon. But the photons get smaller and smaller as the frequency decreases, the energy of a photon being proportional to the frequency, according to Planck's famous equation

$$\text{energy} = h\nu.$$

Thus by the time we reach the frequencies with which practical electricians deal, frequencies which even in these days of short wave radio are only about 10^{11} cycles per second, the photons are so excessively small that any electromagnetic field of reasonable strength contains enormously many photons, so many that their individual effect is entirely lost. We deal with them only statistically, and we may without error replace the discrete photons by the continuous field of Maxwell. For this reason, unless he is dealing with photoelectric cells or some such device, the electrical enginer need hardly come in contact with the theory of photons.

The developments of the other side of electrical theory, the electrical structure of matter, on the other hand, are, and even more promise to be, of great

[1] Address delivered at the Massachusetts Institute of of Technology, March 29, 1933, in connection with the celebration of Professor Elihu Thomson's eightieth birthday.

practical importance. But three examples need be mentioned to make this clear: the development of magnetic theory and magnetic materials, with application to submarine cable construction, the development of the theory of dielectrics, with application to insulating materials, and the development of the theory of electrical conduction and of electrical emission from conductors, with application to vacuum tubes. It can not be claimed that these developments have all been direct results of the theories, but at least they have all had theoretical guidance, and as theory becomes more powerful, as it is doing all the time, it may be expected to serve more and more usefully in suggesting practical advances.

The whole theory of the electrical nature of matter, of course, goes back to the discovery that matter is made of electrons and nuclei. It was really an enormous gain, in clearness of thinking as well as in more practical ways, when it became possible to think of particles of electric charge, instead of states of strain in the ether and such ideas. And physicists lost no time in developing electron theories of matter. Lorentz, doing most of his work shortly before and after 1900, was a leader in this, as were Drude and others. The essence of Lorentz's theory was extremely simple. An electric current consists of the flow of electrons. Since conductors carry current, then, they must contain electrons, free to move from point to point. Experiments on electrons in a vacuum show that they obey the ordinary laws of mechanics, their acceleration being proportional to the force acting on them. Then if there is a difference of potential between two points in a metal, and consequently a force acting on the electrons, they would accelerate, speeding up without limit, if there were not some other force to balance the field. Lorentz made the natural assumption that this other force was of the nature of a viscous resistance, resulting from collisions between the electrons and the atoms. If molecules of a gas, representing the electrons, were moving through a region filled with fixed atoms, the collisions would exert a resistance proportional to the velocity of drift of the electrons, whose magnitude is easily calculated. The motion of the electrons is then very much like the falling of raindrops under gravity. Starting from rest, they are at first rapidly accelerated, but soon they come to a constant speed of fall, in which the gravitational force just balances the viscous force of resistance of the air. This latter force is proportional to the velocity, for small speeds. Hence the external force is proportional to the speed of drift. Similarly in the metal there is proportionality between the electric field and the drift velocity or electric current, and this is the origin of Ohm's law. Lorentz was able by arguments similar to those used in kinetic theory in discussing viscosity, to find the conductivity in terms of the mean free time of electrons between collisions and other simple properties of the system. Thus, let the mean free time be T. Since the acceleration measures the increase of velocity per unit time, the velocity of each electron will increase by an amount aT in the direction of acceleration during its free time. The mean additional velocity imparted by the field will be half this, or $aT/2$. But by Newton's law the force, which is eE, if e is the charge on the electron, E the applied electric field, will equal the mass times the acceleration. Hence $a = eE/m$, the mean velocity of drift is $\frac{eT}{2m}E$, and the electric current density, which is the number of electrons per unit volume times the charge of an electron times the mean velocity, is $\frac{Ne^2}{m}\frac{T}{2}E$. The factor multiplying E is just the conductivity. Lorentz's actual derivation differs from this simple one only in taking account of the variation in free time from one electron to another, the fact that they move in all different directions with different speeds, and such refinements.

In explaining conductivity, Lorentz's theory was perfectly successful, though without independent methods of finding the quantities N and T it could not lead to any new predictions. But there was one rather fatal difficulty with it. Lorentz assumed the electrons to be just like the molecules of a perfect gas, and in particular to have the same temperature, energy and specific heat as a perfect gas. Yet experimentally the specific heat of metals was found to be such that the electrons could have practically no specific heat. That is to say, the experiments indicate that the energy of the electrons does not vary appreciably with temperature, since the specific heat is the increase of energy per degree rise of temperature. This was entirely at variance with Lorentz's theory. It was also in apparent disagreement with the next important experimental and theoretical advance in the theory of metals after Lorentz, namely, the discovery of thermionic emission and its explanation by Richardson.

It was discovered by Edison that metals heated to red heat or beyond emitted electrons, the number increasing very rapidly with the temperature. Richardson provided an explanation of this. He supposed that electrons, like molecules evaporating from a liquid, were pulled back into the metal by a surface force if they tried to escape. As a result, only the fastest electrons could escape, those whose energy was greater than a certain minimum, the energy lost in passing through the surface, or heat of evaporation, since even after escaping the electron must have some energy left. Now the number of electrons with energy greater than a given value φ increases very

rapidly as the temperature increases, according to a formula containing the factor $e^{-\phi/kT}$, where k is Boltzmann's constant, T the temperature, and this factor is the leading term in the experimental equation giving the thermionic current as function of temperature. This equation is deduced on the basis of electrons sharing in the temperature energy, as the molecules of a gas or liquid would, from which we get our analogy of evaporation. And thus its success in predicting the results of experiment seemed to provide a verification of just that feature of Lorentz's theory which was shown by the experiment of the specific heat to be untenable. For some time the theory of metals was in a very difficult and contradictory state, on account of these facts.

The difficulty was solved by means of the wave mechanics, through the work of many physicists, including Pauli and Sommerfeld. The deduction from the specific heat is shown to be essentially correct: the energy of the free electrons is practically independent of temperature, the electrons possessing even at the absolute zero of temperature a rather large amount of kinetic energy, of the order of magnitude of fifteen volts. The principle leading to this result is the same principle, developed by Pauli, which leads to the structure of the atoms, and the periodic table of the elements. An atom contains electrons in a number of shells, some of low energy near the nucleus, some of the higher energy farther out toward the periphery of the atom. We should naturally suppose that at the absolute zero of temperature all electrons would fall into the shell of lowest energy, to liberate all the energy available. They do not do this, however, and this is explained by Pauli's exclusion principle, which limits the number of allowable electrons in each shell, excluding further electrons from entering the shell. The result is that even at the absolute zero the electrons of the atom contain much kinetic energy. The exclusion principle similarly prevents the electrons of the metal from losing all their energy at the absolute zero. Further, a result of the distribution of velocities is that the electron speeds are practically independent of temperature, as the electrons in an atom are practically independent of temperature. Thus the low specific heat of electrons is explained.

The low specific heat, and at the same time the possibility of thermionic emission, are most easily shown to be compatible by using Fermi's distribution of velocities, which is found to be correct rather than Boltzmann's, which is at the basis of the ordinary statistics. The ordinary formula, on which, for instance, Richardson's equation is based, states that the chance of finding an electron with energy E is proportional to $\sqrt{E}\,e^{-E/kT}$. But Fermi's formula is $\frac{\sqrt{E}}{e^{(E-E_0)/kT}+1}$, reducing to the other if the term $+1$ in the denominator is neglected. For any low temperature, the exponential is practically zero if E is less than E_o, infinite if E is greater than E_o, so that the formula gives $\sqrt{E}$ for E less than E_o, zero for E greater than E_o. This is a distribution independent of temperature, explaining the lack of specific heat. The few fastest electrons, however, which could escape, are those for which $E-E_o$ is so great that the exponential is large compared with 1, the formula reducing to Boltzmann's for these fast electrons, so that Richardson's derivation of the thermionic equation can be used practically without change. Some changes are encountered, however, when we try to apply the theory to such things as emission from coated filaments.

The theory as we have sketched it removes the great difficulty with the previous treatment. But in its present development it goes far beyond this. For the first time, it is now proving possible to connect the theory of metallic conduction with the atomic structure of the metal. We are beginning to get some idea of how the electrons actually move between the atoms, what sort of collisions they make, how their behavior is connected with the particular sort of metal we are considering. This theory is far from usable at the present time, but it is rapidly developing, along with similar theories of magnetism and of other electrical properties. It can not be doubted that in a very few years the theory of metallic conduction will be so well worked out that we can describe the mechanism with a great deal of certainty and apply the results in practical ways. The theory is bound to become of more and more use in electrical engineering, and electrical engineers, taking their guidance as in the past from the fundamental discoveries and advances of physics, will not be slow to take advantage of it.

OBITUARY

FREDERIC POOLE GORHAM

FREDERIC POOLE GORHAM, pioneer in bacteriology, nationally-known authority in sanitation and public health, faithful civic servant for many years and great teacher, died suddenly of a heart attack on June 4 in his sixty-third year.

For forty years Professor Gorham served his Alma Mater as teacher, administrator and director of re-

search. He has left his enduring mark on literally thousands of Brown men, particularly on many generations of freshmen, who, entering the class in "Biology 1, 2," oftentimes with hesitancy or indifference, soon came under the spell of his sane enthusiasm.

Of the fifty-six students who have attained the Ph.D. degree at Brown University during the past thirty-two years, twenty-six did their thesis work under his immediate direction. No other member of the Brown faculty has equalled this record. A similar percentage of those who have been granted the master's degree owe their inspiration to his scholarly and sympathetic guidance. These advanced students of biological science have gone out to occupy positions of service and responsibility and they form a living monument of ever-increasing importance to Professor Gorham's memory.

The various extra-academic services to city and state which he has rendered in his long career have been signalized by continuous effectiveness to the very end. For thirty-four years he was bacteriologist for the Providence Department of Health; since 1914 he has been deputy milk inspector for the city; for twenty years he has been an active member of the Rhode Island Shellfish Commission; he was president of the R. I. Tuberculosis Association and secretary of the board of directors of the R. I. State Sanatorium at Wallum Lake; from 1925 to 1931 he served on the Metropolitan Park Commission, and since 1913 he has organized and directed the control of the mosquito nuisance in Providence, expending in this work over a quarter of a million of dollars to the satisfaction of every one concerned.

In all these different exacting activities, which have absorbed vacation-time as well as lengthened every day of the university year, in the face of frequent discouraging lack of appreciation and in spite of the inevitable interference of petty politics, Professor Gorham has steadily and serenely gone ahead with singleness of purpose and unquestioned integrity in the execution of his unselfish philosophy of life.

To quote Dr. H. L. Barnes, superintendent of the state sanatorium, "The time and abilities which he devoted to the State Sanatorium from a busy life, and without compensation, set the highest standard of disinterested public service." And Dr. C. V. Chapin, with whom he worked for years in the health department of Providence, said of him, "He was a man of wonderful judgment and thoroughly grounded in public health work. The beginning of practical bacteriology was Professor Gorham's examination of throats in 1895 for diphtheria control. His knowledge and advice were invaluable in the development of bacteriology. I couldn't say too much for Professor Gorham's work."

He was a fellow of the American Public Health Association and of the American Association for the Advancement of Science. He was chairman of the laboratory section of the American Association of Pathologists and Bacteriologists; past president (1907) of the Society of American Bacteriologists; president of the R. I. Tuberculosis League; member of American Naturalists; Washington Academy of Sciences; Boston Bacteriological Club; Providence Engineering Society, and honorary member of the Rhode Island Medical Society and the Providence Medical Association. Since 1926 he has been the head of the biological department in Brown University.

Among his colleagues and the many students everywhere who have known him intimately it is not so much what he has accomplished during his long useful career, important as that has been, which will be retained in precious memory, as the character of the man himself, a buoyant soul, a true gentleman, a faithful friend.

H. E. WALTER

HARRY HAYWARD CHARLTON

DR. CHARLTON, since 1920 a member of the staff of the department of anatomy of the University of Missouri, died suddenly on the evening of May 31, from complications following an operation. His death came on the eve of his appointment as chairman of the department of anatomy.

Dr. Charlton was born at Allston, Massachusetts, on May 18, 1887. His childhood was spent in Nova Scotia. He then returned to the United States, and his high-school work was done in Lowell, Mass. He received his A.B. degree from Lebanon Valley College, Pennsylvania, in 1914 and the degree of master of arts at Yale in 1916.

During the war Dr. Charlton was retained at Yale as technical assistant in pathology, associated with the Gas Defense Service in the Yale Army School. He served as head of the department of anatomy of Fordham Medical School in 1918–19. He returned to Yale and completed his work for the degree of doctor of philosophy in 1920. He was appointed assistant professor of anatomy at the University of Missouri in 1920, associate professor in 1922 and professor in 1931. He served as secretary of the Missouri Anatomical Board from 1922 to the time of his death.

Dr. Charlton's principal interest in research was concerned with the comparative anatomy of the brain, to which study he made several worth-while contributions. He spent several summers in study at the Biological Laboratory, at Woods Hole, Mass., and

spent a year on sabbatical leave at Professor Ariens-Kappers' Neurological Laboratory in Amsterdam.

Dr. Charlton will be remembered by his students as a sincere, conscientious teacher, exacting but always fair in his evaluation of students' work.

He is survived by his widow, Mary Polson Charlton, and a daughter, Barbara.

EDGAR ALLEN
DEA B. CALVIN
M. D. OVERHOLSER

UNIVERSITY OF MISSOURI

SCIENTIFIC EVENTS

INTERNATIONAL MUSEUMS CONFERENCE AT MADRID

ACCORDING to *Museum News*, the international museums conference at Madrid has been moved from the fall of 1933, as previously announced, to April 4, 1934. It will continue for about ten days and will consider problems of museums and collections of art, archeology, history and popular art.

The subjects to be discussed have been announced by the International Museums Office as follows:

Museum Architecture: (1) General principles of construction, plans and materials, special requirements imposed by purposes of the particular museum, site, environment, arrangements for expansion. (2) Construction of a museum in a historic architectural ensemble. (3) Adaptation of old buildings for museum use.

Arrangement: (1) Exhibition halls. (2) Conference rooms and auditoriums, children's rooms, information and sales rooms. (3) Courts and gardens. (4) Libraries and document rooms, offices. (5) Laboratories, shops for making casts, for photography and restoration. (6) Storage and handling. (7) Caretakers' rooms.

Special Questions: (1) Natural and artificial lighting. (2) Cleaning, heating, ventilation, air conditioning. (3) Protection against fire, theft, earthquake, etc. (4) Custodian service. (5) Floor covering. (6) Coat rooms, buffets, seats, rails and other comforts for visitors.

Presentation of Collections: (1) General considerations in regard to effective exhibition, dimensions and orientation of halls, covering and color of walls, etc. (2) Permanent and temporary exhibitions, exhibits within and without the museum. (3) Presentation of collections—as a whole, selected objects, paintings, combination of paintings, sculpture, furniture, etc., chronological presentation, period rooms and reconstitution of architectural and other ensembles, new acquisitions. (4) Problems caused by enlargement of collections by purchase, gift and bequest, and periodical disposal of unnecessary material. (5) Organization of stored, reserve and study collections. (6) Plans and signs for guidance of visitors. (7) Numbering and labeling. (8) Exhibit material—moldings, cases, hanging methods, protection against vibration, frames, pedestals, movable partitions, rails, etc. (9) Classification and conservation material for drawings, prints, coins, medals, textiles, etc. (10) Publications.

Loans and Exchanges between Museums: Possibilities of collaboration between museums of the same country and between museums of different countries.

An Exhibition of Museum Documents: Plans, photographs, sketches, publications, posters, publicity material.

THE WAWONA ROAD TUNNEL IN THE YOSEMITE NATIONAL PARK

THE recently completed 4,230-foot Wawona Road Tunnel in Yosemite National Park, California, was formally dedicated on June 10. Secretary of the Interior Harold L. Ickes was unable to be present at the ceremonies, but by means of electrical transcription those gathered in Yosemite National Park heard his message of greeting as delivered in Washington.

The new Wawona Road, which extends from near the foot of Bridal Veil Falls to the Mariposa Grove of Big Trees, is approximately 28 miles in length, is on a six per cent. grade, has wide, easy curves, and can be traveled any day in the year. It was built jointly by the National Park Service of the Department of the Interior and the Bureau of Public Roads of the Department of Agriculture.

The driving of the Wawona Tunnel was begun in January, 1931, and was completed in one year. Blasted through cliffs of solid granite, it is 28 feet wide and 20 feet high. The tunnel has three ventilating shafts drilled horizontally to the cliff face. The largest shaft is at the center of the tunnel and contains three large electrically-driven fans which operate automatically, according to the percentage of carbon monoxide gas in the air. These fans are capable of handling 300,000 cubic feet of air per minute. Lights of 4,000 lumens set in deep-bowl reflectors in the roof of the tunnel to within 180 feet of each end give a warm mellow light free from glare. For 180 feet at each end, bulbs of 6,000 lumens give a brighter light to permit vision adjustment.

Parking space for a hundred cars is available near the east portal of the tunnel.

One of the main features of the dedicatory ceremonies was a historical pageant of progress, portraying the evolution of transportation in the Yosemite since its discovery in 1851. The pageant included aboriginal Indians on foot, prospectors with burros, the first tourist horseback parties, lumbering wagons and horse stages, motor stages and 1933 automobiles.

REDUCTION IN FEDERAL AID FOR THE LAND GRANT COLLEGES

ACCORDING to a report by Science Service, federal grants for science and education made to the states

are reduced by $3,917,000 through the reorganization order sent to the Congress by President Roosevelt. The payments for agricultural experiment stations, the cooperative agricultural extension work and the endowment and maintenance of colleges for the benefit of agricultural and mechanic arts, all educational and research funds granted to the states and territories by the federal government are reduced or "abolished" by 25 per cent. These payments, as authorized for the fiscal year 1934 to begin on July 1, amount to $13,119,096 from the Department of Agriculture and $2,550,000 from the Department of the Interior, a grand total of $15,669,096. Under the curtailment ordered to be effective 60 days from the date of the order, June 10, the funds available will be $11,750,000 in round figures.

Under the federal grants for experiment stations much of the scientific research for agriculture accomplished in the various states in the past three decades has been carried on. The appropriations lost to experiment stations under the order amount to $1,095,222. The extension work done cooperatively with the states, supported in part by the federal funds now reduced by 25 per cent., carried the results of the scientific research to the farmers. County agricultural agents are the embodiment of this educational service. The loss is $1,018,000.

The state universities that have carried higher education to thousands in the opening years of this century are supported in part by the Morrill and Smith-Lever Acts, the funds of which are now cut by a quarter of the appropriated amount. Loss to this educational work is $1,804,024.

Federal aid to land-grant colleges has flowed partly through the Department of Agriculture and partly through the Department of the Interior, the latter having been made the agency of a flat sum of $50,000 for the support of instruction in agriculture and the mechanic arts in each state. It seems probable that the curtailment of these funds, which are of long-standing authorization under the Morrill, Hatch, Smith-Lever and other acts, was made by executive order rather than under other provisions of the economy act passed early in the Roosevelt legislative program because by making it a matter of reorganization the 25 per cent. cuts can be made effective for subsequent years rather than just for this year.

CURTAILMENT OF SCIENTIFIC WORK UNDER THE GOVERNMENT

A FURTHER wire report by Science Service states that under the economy act, Budget Director Lewis Douglas, acting for President Roosevelt, is directing still further cuts in the funds for science and education. This results in certain scientific bureaus having for 1934 less than half of what they had two years ago. Inevitably this will mean separations for many highly trained scientific workers engaged in work of great public benefit and extreme salary reductions for many of those who retain jobs. The exact cuts that will go into effect on July 1 are difficult to ascertain, as in some instances even bureau chiefs do not know what funds they will have for the fiscal year that begins in a couple of weeks.

It is known that Secretary of Agriculture Wallace and Assistant Secretary Tugwell are making a strenuous fight to continue the present scientific research for agriculture that they consider to be as necessary for agriculture's return to health as the economic measures being put into effect.

In the Department of Commerce, the U. S. Coast and Geodetic Survey is likely to have its funds cut but little under the figures of the 1934 appropriation bill and it may be selected to administer some of the public works appropriations available under the act just passed. The Bureau of Fisheries will have some cuts, but these are not believed to be serious.

But the Bureau of Standards seems to have been selected for heavy cuts, to such an extent that that bureau may have only about 40 per cent. of the money that it had in 1932. About $3,000,000 spent in 1932 is reduced to $1,336,000 for the 1934 fiscal year, the budget bureau demanding about a third reduction in the slightly more than $2,000,000 available in 1934 appropriation bill.

The Bureau of Mines, also in the Department of Commerce, is to be trimmed to about $1,100,000, whereas the appropriation bill for 1934 carried $1,514,300, and these appropriations for 1934 now reduced were considerably less than the 1932 funds spent for the benefit and safety of the important and valuable mining industry and its resources.

The Geological Survey in the Department of the Interior is also likely to suffer heavily. In 1932 it spent $3,141,000; the 1934 appropriation act provided $1,992,000 and eliminated funds for some of the geological research work of greatest fundamental importance. It is understood that the economy cuts will leave only $1,476,000 available. Some of the important work in topographic mapping, water resources and mineral resources may be salvaged by utilization of public works funds, but it is feared that many of the staff will have to be dismissed and 25 to 30 per cent. of the personnel will be lost through dismissal, retirement or that they will be forced to take unusual amounts of leave without pay.

A weakening of our national defenses against disease is imminent through cuts in the U. S. Public Health Service. A fund of $333,650 for prevention of epidemics is scheduled for reduction to $157,000 and similar cuts in other research funds are contemplated.

SCIENTIFIC NOTES AND NEWS

DR. ALBERT EINSTEIN, who has been visiting the University of Oxford as a research student of Christ Church College, delivered the Herbert Spencer Lecture on June 10 on "The Method of Theoretical Physics." Dr. Einstein will lecture in Belgium during the summer vacation.

THE committee of the Paris Academy of Sciences has voted to present the name of Dr. Pieter Zeeman, professor of physics at the University of Amsterdam, for election to the academy.

THE Academy of Sciences at Heidelberg has elected to membership Dr. Ludwig Aschoff in pathology and Dr. Ernst Zermello and Dr. Gustav Doetsch in mathematics, all of the University of Freiburg.

THE degree of doctor of science was conferred at the commencement of Brown University on June 16 upon Dr. Niels Bohr, professor of physics in the University of Copenhagen, and upon Dr. Lipót Fejér, professor of mathematics at the University of Budapest. The address, made by Dr. Bohr, was entitled "Explanation in Natural Science." He also gave a lecture on "Measurements in Atomic Physics" at the convocation of the Graduate School.

THE Massachusetts State College has conferred the doctorate of science on Dr. Joseph B. Lindsey, who was a member of the staff of the Massachusetts Agricultural Experiment Station for forty-two years and vice-director for twenty-three years, and on Dr. Homer J. Wheeler, Upper Montclair, New Jersey, who was formerly director of the Rhode Island Experiment Station.

WASHINGTON COLLEGE, of Chestertown, Maryland, has conferred the degree of doctor of laws on Dr. Howard A. Kelly, emeritus professor of gynecology at the Johns Hopkins University.

THE degree of doctor of science was conferred at the commencement of Ursinus College on Dr. Guilliam H. Clamer, of Philadelphia, known for his contributions to non-ferrous metallurgy and for his development of electric furnaces.

THE University of Sheffield has conferred the doctorate of science on Professor E. J. Garwood, of the University of London, past-president of the Geological Society of London, and on Professor J. B. Leathes, dean of the Faculty of Medicine of the university.

AT the annual banquet of the Minnesota Chapter of Sigma Xi, held on June 7, the chapter presented to Dr. William J. Mayo, of the Mayo Foundation, Rochester, and to Dean Guy Stanton Ford, dean of the Graduate School of the University of Minnesota, illuminated testimonials in recognition of their service in furthering science and scientific research in Minnesota. The awards were presented by Dr. Louis B. Wilson, national president of Sigma Xi.

THE Distinguished Flying Cross, posthumously awarded to Glenn Hammond Curtiss "for outstanding service rendered to aviation" has been presented to Mrs. Lua Andrews Curtiss, his mother. The presentation was made by Major General Benjamin D. Foulois, chief of the U. S. Army Air Service, at the aviation base at Chapman's Field, Miami.

DR. ALFRED PHILIPPSON, professor of geography at Bonn, and Dr. Erich von Drygalski, professor of geography at Munich, have been awarded Richthofen gold medals. Dr. Ernst Tiessen, professor of geography at Berlin, has received the silver medal.

THE nomination of Dr. Lyman J. Briggs as director of the Bureau of Standards has been confirmed by the Senate.

DR. DUDLEY S. CONLEY, professor of surgery in the School of Medicine of the University of Missouri, will succeed Dean Edgar Allen, who recently resigned to become professor of anatomy and head of the department of anatomy at Yale University.

DR. CHARLES ZELENY, professor of zoology, University of Illinois, has been appointed head of the department to succeed Dr. Henry B. Ward, who has become permanent secretary of the American Association for the Advancement of Science under conditions which permit him to continue research work.

CHARLES JUDSON HERRICK, professor of neurology in the department of anatomy at the University of Chicago since 1907, has been appointed chairman of the department. He succeeds Dr. Robert R. Bensley, who retires with the title of professor emeritus. Dr. Bensley, who went to the university in 1901 as assistant professor of anatomy, has been professor since 1907 and chairman of the department since 1913. He will offer graduate work in the department next year.

CHARLES E. JACKSON has been appointed by President Roosevelt Deputy Commissioner of Fisheries. Since November, 1922, Mr. Jackson has been with Senator E. D. Smith, serving in the capacity of secretary. He succeeds Dr. Lewis Radcliffe, who resigned on April 30, after twenty-six years service with the bureau.

PROFESSOR JUNIUS HENDERSON, of the University of Colorado, curator of the museum since 1903, has retired at the age of sixty-eight years. He was given a farewell banquet by the informal senate of the university, when speeches were made by the vice-presi-

dent, the dean of the graduate school and heads of various departments. Dr. Henderson plans to spend a year in California. He is succeeded by Hugo G. Rodeck, who will hold the academic rank of assistant professor.

AT the University of Bristol Dr. J. F. Baker, technical officer to the British Steel Structures Committee, has accepted an invitation to fill the chair of civil engineering in succession to Professor A. J. S. Pippard, who resigns at the end of the current session, and Professor A. E. Trueman, professor of geology at University College, Swansea, has been appointed Chaning Wills professor of geology in succession to Professor S. H. Reynolds, who retires at the end of the year.

DR. ALEXIS CARREL, of the Rockefeller Institute for Medical Research, sailed for France on June 10.

DR. JOHN C. MERRIAM, president of the Carnegie Institution of Washington, gave the commencement address on June 12 at the Carnegie Institute of Technology, Pittsburgh.

THE first public meeting of the new chapter of Sigma Xi in the University of California at Los Angeles was addressed on May 24 by Professor Niels Bohr on "Space-Time Relations in Atomic Physics."

DR. HERBERT DINGLE, professor of astrophysics in the Imperial College of Science and Technology, London, and research fellow in the California Institute of Technology, 1932–33, on June 7 lectured on "The Nature of Scientific Thought" at the University of California at Los Angeles, under the auspices of the department of astronomy.

SIR HENRY HADOW gave the Romanes lecture for 1933 at the University of Oxford, on May 31. The title of the lecture was "The Place of Music among the Arts."

PROFESSOR OTTO HAHN, the George T. Baker nonresident lecturer in chemistry at Cornell University during the spring semester, delivered three lectures at the University of Minnesota on June 5, 6 and 7—before the Minnesota Section of the American Chemical Society on "Gaseous Radioelements and their Application in Chemical Research," before the Colloquium of the School of Chemistry on "Co-precipitation and Adsorption Processes" and before the annual meeting of Sigma Xi on "From the Ponderable to the Imponderable." Professor Jan Heyrovsky, of the Charles University of Prague, gave three lectures before the colloquium on the "Theory and Practise of the Polarigraphic Method" on June 8, 9 and 10.

THE *Journal* of the American Medical Association reports that the Gorgas Medical Society of New Orleans has awarded honorary fellowships as follows: to Dr. Arthur Vidrine for his work in surgery; to Dr. Joseph Rigney D'Aunoy for his work on electrocardiography and to Dr. Richard Ashman for achievement in research. The awards are made to those "who have distinguished themselves in medical science and research." Dr. Vidrine is dean of the medical center of the University of Louisiana, Dr. D'Aunoy is professor of pathology and bacteriology and executive secretary of the center and Dr. Ashman is professor of physiology. These fellowships are the first to be awarded by this society, which was organized last year by Dr. Clyde Brooks, professor of pharmacology and experimental therapeutics.

THE twenty-first Wilbur Wright memorial lecture was read by Colonel F. P. Lahm, Air Corps, U. S. Army, on May 30, before the Royal Aeronautical Society at its meeting held in the Royal Institution. Before the lecture the following medals were presented by the president, C. R. Fairey: the gold medal of the society, to Sir Richard Glazebrook, on his retirement from the chairmanship of the Aeronautical Research Committee, which he has held since the foundation of the committee in 1909; the Simms Gold Medal, for the best paper read before the society on any science allied to aeronautics, to Mr. P. Salmon, for his paper on catapults; the Wakefield Gold Medal, for inventions or apparatus tending towards safety in flying, to Mr. L. G. Frise, for his invention of the Frise aileron; the Taylor Gold Medal, for the most valuable paper of the year, to Dr. G. V. Lachmann, for his paper on "Control beyond the Stall"; the Silver Medal, for advance in aeronautical design, to each of the following: Señor J. de la Cierva, for his work in the design and development of the autogiro; Mr. A. H. R. Fedden, for his work on the air-cooled engine, resulting in the attainment of a record height of over 40,000 feet in September, 1932; Mr. D. L. Hollis-Williams, who was responsible for the design of the Fairey long-range monoplane which holds the world's long-distance record of 5,309 miles. The newly-founded British Silver Medal for Aeronautics, to Flight Lieutenant C. F. Uwins, for reaching the world record height in September last, and to Squadron Leader O. R. Gayford and Flight Lieutenant G. E. Nicholetts, who flew non-stop from Cranwell to Walvis Bay in the long-distance monoplane.

ACCORDING to the *Journal* of the American Medical Association, at the general meeting of the Imperial Academy of Japan, the special committee announced the awards of the imperial prizes and others for 1932. The imperial prizes were given to Dr. J. Tsuji, of the Physical and Chemical Research Institute, for his researches on the elasticity of light, and to Professor B. Suzuki, D.Sc., of the Kyoto Imperial University, for his work on fatty acids. The academy

prize was awarded to Professor M. Ishimoto, of the Tokyo Imperial University science department, for his seismological observations. The emperor's wedding commemoration prizes, contributed by the Osaka *Mainichi*, were given to Professor S. Kusano, of the Tokyo Imperial University, for his work on fungi; to Professor C. Oguchi, of the Nagoya Medical College, for his research on Oguchi's disease, to Professor Y. Furutake, of the Osaka Imperial University, for his discovery of kynurenin, a crystal chemical compound, and to Professor H. Nomura, of the Sendai University, for his study on the pungency of ginger.

ACCORDING to the *Astronomische Nachrichten*, the division of the Astrophysical Observatory in Potsdam that has been called the Einstein Institute will by decree of the ministry be hereafter known as the Institute for Solar Physics.

ANNOUNCEMENT has just been made at Harvard University that the Institute of Geographical Exploration has been given a valuable library collection which includes several rare accounts of early voyages of exploration and discovery in America. The collection is stated to be the most important single addition which has yet been made to the library on geographical exploration. Numbering nearly 1,000 separate items, the collection has been presented to the university by Mrs. Joseph Tuckerman Tower, of Millbrook, New York. It includes principally books, maps and documents which were collected by her son, Joseph Tuckerman Tower, Jr., of the Harvard College Class of 1921, who died in Mexico in 1931. Before his death Mr. Tower had planned the gift of his collection to the institute at Harvard. In addition to many rare and valuable old books on early voyages, the library includes sections dealing with Arctic exploration, exploration in Alaska, Iceland and in the Hudson Bay region.

THE Board of Governors of the Institute of Medicine of Chicago recently authorized an appropriation of $1,455 to compile a combined card catalogue of the literature in the medical libraries of Chicago (John Crerar, Rush Medical College and the medical colleges of the universities of Chicago, Illinois, Loyola and Northwestern). The plan was organized and the work is being carried out under the supervision of Otto F. Kampmeier, professor of anatomy at the University of Illinois, and chairman of the committee on coordination of medical libraries in Chicago. The union index will be completed in six to eight months, and will be placed in the John Crerar Library because of its central location in the city.

AN additional one hundred and ninety acres of marsh and prairie land have been added to the University of Wisconsin arboretum. Funds made available by the Tripp estate have made acquisition of this land possible. The new tract adjoins the present arboretum land on the south and west, and increases the total area of the arboretum to slightly more than 400 acres. Addition of the new area to the present arboretum gives the university and the State of Wisconsin an excellent opportunity for experimentation in reforestation and propagation of wild life. Acquisition of several tracts deemed essential to the project permitted the Board of Regents to establish the Wisconsin arboretum last August, after nearly six years of constant work on the part of regents, university officials and public-spirited Wisconsin citizens. No state appropriated funds whatever have been used on the project. Acquisition of the original tract of 235 acres was also made possible through use of the residue of the estate of the late J. Stephens Tripp, who left his entire estate to the university. Other groups of citizens donated land also. The committee in charge of the arboretum consists of Professors E. M. Gilbert, George Wagner, James G. Dickson, Chancey Juday, N. C. Fassett, Leon J. Cole and J. W. Jackson, Associate Franz A. Aust, Instructor F. B. Trenk, Superintendent A. F. Gallistel, Secretary M. E. McCaffrey. In addition to this active committee the president has appointed an advisory committee consisting of Dr. E. A. Birge, Dr. H. L. Russell, C. P. Winslow, Aldo Leopold, Paul D. Holleter and Professor Raphael Zon.

THE thirty-seventh annual report has been issued of the New York Zoological Society, which maintains the Zoological Park in the Bronx, the Aquarium and the tropical research station. The report of finances states that the City of New York appropriated $418,891 toward the maintenance of the Zoological Garden and the Aquarium during 1932. During the year the society expended $227,730. The endowment and other funds are $4,123,637, of which $4,035,386 is represented by securities carried at cost or gift value. The market value on December 31 was $3,157,173. "For the continuation of its work," according to the report, "the society requires the immediate addition of $2,000,000 to its general endowment, and desires the constant attention of its members and friends to the needs of its library, extension of its scientific research work, heads and horns collection, publications and gallery of animal paintings."

AS the result of a proposal made by Dr. Schaffernak, of Austria, at the World Power Conference at Berlin in 1930, that "an organization be established for the purpose of interchanging, in the field of hydraulic engineering, the results of laboratory research and of observations of natural conditions corresponding thereto," the American committee of the World Power Conference asked the Bureau of Standards last January to serve as the exchange agency for the

United States. The object of the proposed organization is to afford promptly to all the hydraulic laboratories throughout the world information as to the nature of the research which each is undertaking, thus permitting a closer coordination of the work. The first step in organizing this service nationally in the United States was to compile and distribute to the hydraulic laboratories in this country a report covering the activities of these laboratories. As a result of the prompt cooperation of the individual laboratories, it was possible for the bureau to issue on April 1 its first report of this kind, a mimeographed bulletin entitled, "Current Hydraulic Laboratory Research in the United States." The second report will be issued on July 1, and succeeding numbers will appear quarterly. In addition to the above service, the bureau will compile and issue annually a description of the hydraulic laboratories in the United States, their equipment and facilities for research in so far as the heads of the laboratories will furnish the necessary information. It is planned to issue the first report of this kind on June 1.

DISCUSSION

AN ELECTRIC ANALOGUE OF VOWEL PRODUCTION

IT is of interest to examine the results of the remarkable if somewhat bizarre experiment of Travis and Buchanan,[1] which relates to the production of sound frequencies in the voice, in the light of our knowledge of analogous electric circuit behavior. The mathematics of the electric circuit is remarkably well developed, and since in many cases a strict analogy may be demonstrated between sound vibrations and electric vibrations, it is hoped that in the present study a consideration of this mathematics will prove significant.

First, the possible appearance in the output of vibration frequencies that are entirely absent in the motive force should be considered, that is, the appearance of frequencies in the voice that would not appear in the vibration of vocal cords in the open. Or, in terms of this particular experiment, the change of wave-form when a pure sine wave is passed into the resonating cavities.

There is no doubt that such a change is possible. It is the result of non-linear response of some of the elements involved in the propagation of sound, and appears when a strictly sinusoidal stress does not result in a strictly sinusoidal strain in either the vibrating medium or the containing walls. The irregularity of the vocal passage and the non-homogeneity of the walls make a somewhat non-linear response certain, but the amount of the change of wave-shape is unknown. The amount of the change at any one point may be small, but if any of the chief frequencies thereby introduced should find a resonating cavity of the same natural frequency, the amplitude of such frequency will be greatly increased. It should also be noted that the vibration of the vocal cords is not entirely independent of the resonant system in which they operate, although for practical purposes it is very nearly so. It is to be expected that the distortion of loud sounds is greater than that of soft ones.

[1] SCIENCE, 77: 121, January 27, 1933.

Second, the magnification, in the output, of small irregularities in the input must be considered. An abrupt change in the input motion, a discontinuity, will produce resonance in all cavities, but in amounts varying with the natural frequency, location and size of the cavity. An irregular, or non-sinusoidal input will have a similar effect. So will a wave whose steady-state condition is sinusoidal, when it is starting or stopping. All three of these means of producing resonance will doubtless occur in the normal voice. Only the second will be appreciable in the experiment, as described, with the oscillator; but it is evident that the input can not be mathematically exact even under the most favorable experimental conditions, and there is no mention of a determination of the exact wave-form in detail.

Finally, the relative amounts of frequencies introduced by the two means should be considered. The first, the distortion due to non-linear response of the vocal passages, can produce energy of one frequency only at the expense of decreasing energy of another frequency. The more audible a frequency is, the more it is being damped by losing energy as output. From these considerations, and from the nature of the system, it is improbable that resonance in the sinusoidal steady-state condition could introduce frequencies with amplitudes of more than a few per cent. of the fundamental.

The second type of distortion, due to transient conditions or to non-sinusoidal input, will give resonant vibrations that depend for their energy on a component vibration of their own frequency in the input. Hence, as they also are damped by the output, their amplitude with an approximate sine-wave input may be of the same order of magnitude as the steady state distortion.

So both "steady-state" and "transient" production of resonant frequencies appear to be possible. In either case a small amplitude may be magnified to many times its original amount by resonance, and from the published data it seems impossible to tell

which type of distortion produces the resonance detected by Travis and Buchanan.

HUGH SKILLING

STANFORD UNIVERSITY

NOMENCLATURE OF THE VEGETABLE WEEVIL

THIS interesting weevil is one of the many insects which has recently emerged from natural obscurity and has appeared as an economic pest on three continents during the past twenty-five years, it having originated on a fourth. Its native habitat is the southern half of South America, from which area it has been carried by commerce to Australia, North America and Africa.

The first specimens were collected more than one hundred years ago on Magellan Strait and were described as *Listroderes costirostris* by the Swedish entomologist Schoenherr[1] in 1826. An aberrant form was later named *L. obliquus* by Gyllenhal[2] in 1834. There appears to be some confusion regarding the authority of *L. costirostris,* for in this latter publication, "Schoen. Gen. et Spec. Curcul.," vol. 2, p. 277, 1834, by L. Gyllenhal, and also in vol. IV, p. 189, 1842, by C. H. Boheman, the species is credited to Gyllenhal rather than to Schoenherr. L. L. Buchanan, U. S. Bureau of Entomology, very kindly looked up the original descriptions by Schoenherr and furnished the following information:

In 1826, Schoenherr ('Curculionidium disposito methodica . . . ,' page 158) erects *Listroderes* as follows:—'Genus 82. *Listroderes* nob.—*Merionus* Dej. *Character generis*:—' (12 lines of descriptive matter). Then, '*Descriptio*:' (Remainder of page 158 and more than half of page 159 taken up with a detailed description). Then, '*Typus*: *Listrod. costirostris* Gyllenh. n. sp.

Schoenherr's purpose here evidently was simply to describe a new genus, but the description, being based on one species, really amounts to a combined generic description of *Listroderes* and a specific description of *costirostris.* Under these conditions, it seems to me proper to consider *costirostris* as having been described by Schoenherr in this paper.

In 1881 Berg[3] gave some additional information regarding the weevil and listed it from the region of the Rio Colorado in central Argentina, but wrongly listed *Listroderes robustus* Waterhouse as a synonym of *L. costirostris.* Hustache[4] credited the species to Gyllenhal, and to its distribution adds Buenos Aires with the statement that the range extends northwards to meridional Brazil. His figure of *L. vicinus* Hust., pl. II, is very much like *L. costirostris.*

In 1908 this same weevil was discovered in South Australia, where it was described as a new species, *Desiantha nociva,* by Lea[5] in 1909. Along the eastern and southern coasts of that continent it soon became known as a pest of considerable economic importance to vegetable crops and to fruits and was generally called the buff-colored tomato weevil.[6] It was not until years later that the weevil was known to be of South American origin.

On the North American continent the weevil was first recognized as a newly introduced pest of truck crops at McHenry, Mississippi, on March 28, 1922, and was determined as the Australian tomato weevil and first listed as *Listroderes* (*Desiantha*) *nociva* (Lea).[7] Later it was designated scientifically simply as *Desiantha nociva* Lea.[8] Further studies and comparisons with known species convinced Chittenden that the weevil was *Listroderes obliquus,* which he credited to Fabricius.[9] It was also known as *Listronotus obliquus,* and is not to be confused with the American species by that name.[10] In 1926 the same species was discovered attacking vegetables at San Jose, California, and within a few years was known to occur in much of the San Francisco Bay region.

The very same weevil was recorded in South Africa in 1924, having been previously introduced into Port Elizabeth,[11] where it was found to be injuring turnips.

This rapid and wide distribution has no doubt been due to the transportation of infested vegetables from South American seaports used in ships' stores, and it is not unlikely that all these different foci of infestation have a more or less common origin.

Although the insect has generally been scientifically known as *Listroderes obliquus* (Gyll.),[12] Schenkling

[1] C. J. Schoenherr, "Disp. Meth. Curculionidum," p. 158. 1826.

[2] L. Gyllenhal, "Schoen. Gen. et Spec. Curcul.," vol. 2, pt. 1, p. 277. 1834.

[3] C. Berg, "Entomologisches aus dem Indianergebeit der Pampa." *Stett. Ent. Zeit.,* 42: 62, fig. 10. 1881.

[4] A. Hustache, "Curculionides de la Republique Argentine." *Ann. Museo Nacionale de Hist. Nat.,* Buenos Aires, 34: 199. 1926.

[5] A. M. Lea, *Trans. and Proc. Royal Soc. So. Austr.,* 33: 174–175. 1909.

[6] C. French, Jr., Handbook Destr. Ins. Victoria, pt. V, pp. 41–43, Oct., 1909; W. W. Froggatt, "The Buff-colored Tomato Weevil (*Desiantha nociva*)," *Agr. Gaz. N. S. W.,* Sydney, xxvi: 1065–1066. 1915.

[7] R. W. Harned, "A New Potato Weevil in Mississippi." *Quart. Bul. State Pl. Bd. Miss.,* 2: 1–2, pp. 6–8, 11–12. 1922.

[8] E. K. Bynum, "Controlling the Australian Tomato Weevil, *Desiantha nociva.*" *Ibid.,* 3: 1, pp. 22–24 (1923); F. H. Chittenden, "The Australian Tomato Weevil, Introduced in the South," U. S. Dept. Agr., Dept. Circ. 282, 8 pp., 6 fig. July 31, 1932.

[9] F. H. Chittenden, "An Introduced Weevil Related to the Vegetable Weevil." *Proc. Biol. Soc. Wash.,* 39: 71–74, pl. 1. 1926.

[10] An entirely different weevil, *Listronotus obliquus,* was described from Texas in 1876 by J. L. LeConte. *Proc. Am. Philos. Soc.,* 15: 128, 129. 1876.

[11] *Jour. Dept. Agr., Union South Africa,* 8: 3, pp. 264–265. 1924.

[12] E. O. Essig, "The Vegetable Weevil." "A History of Entomology," pp. 203–206, figs. 78–81 (Bibliography). New York: Macmillan. 1931. O. H. Lovell, "The Vegetable Weevil, *Listroderes obliquus.*" *Calif. Agr. Expt. Sta., Bull.* 546, 19 pp., 5 figs., December, 1932.

and Marshall,[13] in 1931, corrected the systematic nomenclature and have listed the species as *Listroderes costirostris* Schoenherr. As to the advisability of adopting this specific name in America, Buchanan has also kindly given his views as follows:

> The citing of *obliquus* in the Schenkling catalogue as an aberration ('ab.') indicates that the compilers regard it as some sort of a subordinate form, but not an absolute synonym, of *costirostris;* and, until the two are found to be synonymous through an examination of the type specimens or through other means, it would seem preferable to continue the use of the name *obliquus* Gyll. in North American literature, either as *obliquus* alone or as *costirostris* ab. *obliquus.*

The common name, vegetable weevil, was approved by the American Association of Economic Entomologists in 1931.[14]

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NOMENCLATORIAL NOTES ON GASTROTRICHA

(1) THE genus *Dactylopodola* Strand:

Dactylopodella Remane, 1926, *Zeits. Morph. Ökol.,* 5: 664 non G. O. Sars, 1905, Crust. Norway, 5: 131 (Copepoda).

Dactylopodola Strand, March, 1929, Acta Univ. Latv., 20: 5.

Dactylopodalia Remane, 30 May, 1929, Kükenthal and Krumbach, Handb. Zool., 2 (4): 130.

Professor Embrik Strand kindly informed me personally of the month of publication of his paper. As a consequence of the above synonymy it is necessary to form the new family name Dactylopodolidae in place of Dactylopodellidae Remane 1927 and Dactylopodaliidae Remane 1929, and also the new combinations *Dactylopodola baltica* (Remane) and *Dactylopodola typhle* (Remane).

(2) *Lepidodermella* nom. nov.:

Lepidoderma Zelinka, 1889, *Zeits. wiss. Zool.,* 49: 300 non Reuss, 1856, Denks. Akad. Wiss. Wien, 10: 83 (Eurypterida).

As I can not find that this homonym has ever been corrected, I propose here as a substitute the name *Lepidodermella.* We have, hence, the new combinations *Lepidodermella squammata* (Dujardin), *Lepidodermella concinna* (Stokes), *Lepidodermella ocellata* (Metschnikov) and *Lepidodermella zelinkai* (Konsuloff).

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[13] S. Schenkling and G. A. K. Marshall, "Curculionidae: Cylindrorrhininae." Coleopterorum Catalogus (Berlin, Junk, 1931), pars. 114, p. 7, Feb. 12, 1931. (Bibliography.)

[14] *Jour. Econ. Ent.,* 24: 1291, 1303. 1931.

MALVACEOUS PLANTS AS A CAUSE OF "PINK WHITE" IN STORED EGGS

A TYPE of deterioration in stored eggs in which the egg white becomes pink, and the yolk becomes large, salmon colored and watery in consistency, but turns rubbery when cooked, has caused severe losses in the United States in past years. Eggs from hens fed raw cottonseed products have been known to suffer the same or a similar type of deterioration, but most examples of "pink white" eggs on the market have come from flocks to which cottonseed products were not available.

It was discovered in this laboratory that the extracted yolk fat of "pink white" eggs, and also of fresh eggs from hens fed cottonseed oil gave the Halphen test for cottonseed. It was also discovered that seeds of certain members of the family Malvaceae (other than cotton) notably *Malva parviflora, Lavatera assurgentiflora* and *Althaea sp.* gave positive Halphen tests. Consequently, groups of hens were fed rations containing seeds of *Malva parviflora* and of *Lavatera assurgentiflora.* Eggs from these birds gave a positive Halphen test and also turned pink after a period of storage, while eggs from the same birds, before the seeds were added to the rations, gave a negative test and did not turn pink after the same period of storage.

It is concluded that these and possibly other members of the family Malvaceae when eaten by laying hens may become responsible for "pink white" deterioration in stored eggs. *Malva parviflora* is a common weed in poultry districts and is more available to poultry than other members of the family, so that this species is probably the important cause of "pink white" deterioration.

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INCOMPLETE NUCLEAR DIVISIONS AND NOT AMITOSIS IN THE TAPETUM OF THE EUSPORANGIATE FERNS

IN 1913 the writer began an investigation of the nature of the nuclear divisions in the tapetum of *Botrychium virginianum* (L.) Swarz. He was soon led to the conclusion that the nuclei undergo incomplete divisions similar to those described by him in *Nephrodium hirtipes* Hk.[1]

As a result of this investigation, extending over a period of two decades, the writer has been convinced that the amitotic divisions described by some workers as occurring in the tapetum of the *eusporangiate* filicales do not take place.

[1] W. N. Steil, "Apogamy in *Nephrodium hirtipes* Hk." *Ann. Bot.,* 33: 109–133, 1919.

The incomplete nuclear divisions, which begin in the young tapetum, result in the formation of nuclei of irregular form, commonly, dumb-bell and kidney-shaped, which have suggested to some workers that the nuclei divide amitotically. The nuclei, as a result of successive incomplete divisions, are polyploid and of unusually large size.

The organization of chromosomes, the presence of spindle fibers and various stages in the reorganization of the resting daughter nuclei are some of the evidences that incomplete divisions, and not amitotic divisions, occur in the tapetum.

The incomplete nuclear divisions herein described have been studied in two *eusporangiate* ferns, namely *Botrychium virginianum* (L.) Swarz and *Ophioglossum vulgatum* L.

A detailed discussion of these nuclear divisions in the tapetum of the ferns studied will be presented in the near future.

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THE FOURTEENTH ANNUAL MEETING OF THE AMERICAN GEOPHYSICAL UNION

THE fourteenth annual meeting of the American Geophysical Union and the sessions of its sections were held at Washington, D. C., on April 27, 28 and 29.

Progress-reports on geodetic work in the United States and Mexico were presented before the Section of Geodesy, as also papers on gravity-work, on application of radio to astronomical longitude-determinations of the Geodetic Survey of Canada, on the moon's influence on latitude and on the expansion and developments in the time-service at the U. S. Naval Observatory.

The Section of Seismology of the union held a joint meeting with the Eastern Section of the Seismological Society of America. An interesting series of progress-reports, papers and informal communications, totaling 39, was presented at the three sessions of this joint meeting, including, among others, progress-reports on developments of seismological instruments and on the work of various seismograph-stations in the United States and Mexico; papers relating to recent earthquakes, to discussion of methods in seismological determinations, and to precise geodetic measurements and their relation to seismological investigations; and an informal discussion of earthquake-code.

At its meeting the Section of Meteorology had the privilege of hearing a paper by Dr. L. Vegard, of Norway, on the auroral spectrum, in addition to papers by members of the union and other guests on meteorological problems in relation to radiation, on trade-winds of the eastern Caribbean, on reduction of meteorological data from Cruise VII of the *Carnegie*, on interesting facts concerning warm and cold waves, on the value of cloud-observations, on the Giao theory explaining the formation of precipitation in relation to fundamental concepts of the polar-front theory, on turbulence-factors of Linke and Ångstrom and their practical applicability, and on the time, type and areal distribution of tornadoes in the United States.

The reports and papers presented before the Section of Terrestrial Magnetism and Electricity included progress-reports on the year's investigations and projects in the United States, Canada and Mexico and on the International Polar Year of 1932–33, while the papers related to cosmic rays, to earth-resistivity measurements, to ozone and the sunspot-cycle, to cosmic radio correlations and to effect of magnetic activity upon secular change.

As in past years, the meeting of the Section of Oceanography consisted mainly of the progress-reports of eight governmental bureaus and private research organizations engaged in oceanographic work in the United States and Canada. Besides these reports, there were papers on the submarine valleys of the Bahamas, on submarine mock valleys, on investigations of submarine valleys, on monthly sequence of sea-surface temperature on the New York-San Juan steamship route, on air- and water-temperatures in the West Indian region, on development of our conception of the Gulf Stream system and on data from borehole on New Providence Island, Bahamas.

In the Section of Volcanology the papers dealt with volcanic explosions and overthrusts, with the Tertiary Volcano at Cripple Creek, Colorado, and the volcano of Santa Maria in Guatemala, with some features of volcanic sequence in the Cascade Region in Oregon, and with volcanic history of the Magdalena District, New Mexico.

The Section of Hydrology devoted three sessions to hearing reports of its nine permanent research committees and 25 papers covering numerous investigations and developments in scientific hydrology throughout the United States. These brought out clearly the effective cooperation existing between the various hydraulic stations and laboratories of the federal government, of the state governments, of universities and of consulting engineering organizations.

At the business session of the general assembly the general secretary reported a total membership of 355, as of April 28, 1933. Among other things, the gen-

eral secretary also reported briefly on relations of the union with the international body and on the progress of the International Polar Year of 1932–33. His report showed that interest in geophysics during the past year has continued its rapid growth—a growth to which the union has made substantial contribution.

The following nine resolutions were unanimously adopted:

(I) *Resolution on the death of Robert Lee Faris,* proposed by the Sections of Geodesy and Terrestrial Magnetism and Electricity:

WHEREAS, By the death of Robert Lee Faris on October 5, 1932, the American Geophysical Union has lost one of its original members and a former Chairman of the Section of Geodesy, and

WHEREAS, Captain Faris was interested in many departments of geophysics and helped to advance scientific knowledge not only by his personal efforts in field and office, but also by the influence he was able to exert through the numerous and important administrative positions held by him, and not least by means of his personal character, which won for him the respect and friendship of those with whom he came in contact, therefore be it

Resolved, That the American Geophysical Union, in general meeting assembled, hereby expresses and places on record its sense of loss through his death; and be it further

Resolved, That copies of this resolution be sent to Mrs. Faris, to the Director of the U. S. Coast and Geodetic Survey, and to Chairman of the Mississippi River Commission.

(II) *Resolution on the death of John Ripley Freeman,* proposed by the Sections of Seismology and Hydrology:

WHEREAS, In the death of John R. Freeman the American Geophysical Union has lost a pioneer in the fields of hydrology, geology, and seismology as related to engineering problems, and

WHEREAS, He has rendered notable services to his profession by his generosity in providing traveling scholarships in hydraulics and in financing the translation and publication of foreign books and papers on hydraulics, and by his untiring efforts toward the establishment of a National Hydraulic Laboratory, and

WHEREAS, He through publication and otherwise has greatly stimulated interest in seismology, especially in applications toward saving life and property; therefore be it

Resolved, That the American Geophysical Union expresses its sense of great loss in the death of John R. Freeman, not only because of his high engineering and scientific attainments, but also because of his outstanding personal qualities and his earnest and continuous efforts to advance the profession to which his whole life has brought honor; and be it further

Resolved, That a copy of this resolution be sent to Dr. Freeman's family.

(III) *Resolution on the death of Harlan Wilbur Fisk,* proposed by the Section of Terrestrial Magnetism and Electricity:

WHEREAS, In the death of Harlan Wilbur Fisk the American Geophysical Union has lost a member long identified with the affairs of the Union and active especially, as both member and officer, in the Section of Terrestrial Magnetism and Electricity, and

WHEREAS, He rendered important service to the advancement of geophysics, particularly through his extensive participation in the magnetic survey of the Earth and through the interpretation of the results thus obtained; therefore be it

Resolved, That the American Geophysical Union records this expression of its sense of profound sorrow on the death of Harlan Wilbur Fisk; and be it further

Resolved, That a copy of this resolution be sent to Professor Fisk's family, to the President of the Carnegie Institution of Washington, and to the Acting Director of the Department of Terrestrial Magnetism.

(IV) *Resolution on the death of Louis Winslow Austin,* proposed by the Section of Terrestrial Magnetism and Electricity:

WHEREAS, The death of Louis Winslow Austin has removed from the American Geophysical Union a member always actively interested in the affairs of the Union and one who made notable contribution to geophysics through radio-transmission research and its interpretation in relation to terrestrial magnetism and other geophysical phenomena; therefore be it

Resolved, That the American Geophysical Union records this expression of its sense of great loss in the death of Louis Winslow Austin; and be it further

Resolved, That a copy of this resolution be sent to Dr. Austin's family, to the Secretary of the Department of Commerce of the United States, and to the Director of the United States Bureau of Standards.

(V) *Resolution on International Polar Year,* proposed by the Section of Terrestrial Magnetism and Electricity:

WHEREAS, The American Geophysical Union regards with satisfaction and approval the progress made in carrying out the International Polar Year program and appreciates the great value of the results that have been and will be obtained during the Polar Year; therefore be it

Resolved, That the American Geophysical Union expresses the hope that the International Polar Year Commission will be able to find means for complete analysis, discussion, and distribution of the geophysical data resulting from this magnificent international effort, and that the United States, through its government or otherwise, will be able to assume its proper share in this work; and be it further

Resolved, That copies of this resolution be sent to the President of the International Polar Year Commission and to the President of the National Academy of Sciences with the request that the latter make such disposition of this resolution as he may find most effective.

(VI) *Resolution on cosmic rays*, proposed by the Section of Terrestrial Magnetism and Electricity:

WHEREAS, The importance of studies of cosmic rays is steadily increasing and the need for their continuous registration has been demonstrated; therefore be it

Resolved, That the American Geophysical Union recommends that support wherever possible be given to the plan of the Carnegie Institution of Washington and cooperating agencies to establish at certain fixed observatories apparatus and equipment for recording cosmic rays photographically and continuously; and be it further

Resolved, That a copy of this resolution be sent to the President of the Carnegie Institution of Washington with the request that he furnish copies to the cooperating agencies.

(VII) *Resolutions proposing an International Commission on the Hydrology of Snow and Ice*, proposed by the Section of Hydrology:

WHEREAS, The hydrology of snow and ice and the methods of making snow-surveys constitute an important field in the science of hydrology, with a considerable number of research workers in the subject wisely distributed in different parts of the world, and

WHEREAS, There is at present no international commission that covers this field; therefore be it

Resolved, That the American Geophysical Union hereby expresses the hope that the International Association of Scientific Hydrology will take appropriate steps at the forthcoming meeting in Lisbon to create a Commission on the Hydrology of Snow and Ice; and be it further

Resolved, That a copy of this resolution be sent to the Secretary of the International Association together with copies of the annual reports for 1932 and 1933 of the Committee on Snow of the Section of Hydrology of the American Geophysical Union.

(VIII) *Resolution on appropriations for scientific investigations by the Federal Government*, proposed by the Section of Seismology:

WHEREAS, There are certain types of investigation which can be carried on effectively only by the Federal Government, and

WHEREAS, Large economies accrue to the Government itself from those investigations, and

WHEREAS, Private engineers, geophysicists, and others are almost absolutely dependent on the results of those investigations for the continuance of their own work; therefore be it

Resolved, That the American Geophysical Union expresses its hope that the scientific work of the Federal Government will not be too much curtailed under the stress of economic conditions; and be it further

Resolved, That a copy of this resolution be sent to the President of the National Academy of Sciences for such use as the Academy may think proper in its capacity as official advisor to the Federal Government.

(IX) *Resolution on Naval Observatory time-signals*, proposed by the Section of Seismology:

WHEREAS, Accurate time-signals sent out from a strong radio broadcasting station many times daily are necessary for seismological and other geophysical observations, and

WHEREAS, The United States Naval Observatory is now broadcasting such signals seven times daily; therefore be it

Resolved, That the American Geophysical Union expresses its appreciation and gratitude for this service; and be it further

Resolved, That this resolution be printed in the transactions and that a copy be sent to the Superintendent of the United States Naval Observatory.

The scientific session of the general assembly was devoted to a symposium on relations of hydrology to other branches of geophysics, and included the following papers: (a) "The Relation of Hydrology to the Botanical Sciences," by R. E. Horton; (b) "Relation of Meteorology to Hydrology," by N. C. Grover; (c) "Distribution of Precipitation in the Cumberland and Tennessee Basins," by M. W. Hayes; (d) "Glaciers and Geophysics," by Harry Fielding Reid; (e) "Some Relations between Ground-water Hydrology and Oceanography," by D. G. Thompson; (f) "Oceanography and Hydrology," by G. F. McEwen; (g) "Relation of Seismology to Hydrology," by N. H. Heck; (h) "Geophysical Interpretation of Ground-water Levels," by O. E. Meinzer; (i) "Associated Problems in Hydrology and Terrestrial Electricity," by O. H. Gish.

The marked success of the fourteenth annual meeting of the union and of its sections hinged largely upon the excellent program developed by the committee on meetings, consisting of Messrs. H. A. Marmer (*chairman*), R. M. Field, R. E. Gibson, F. W. Sohon, S.J., and H. F. Johnston.

The manuscript for the planographed volume of the complete *Transactions* of this meeting is already in preparation, and it is hoped that the volume may be issued during July.

JNO. A. FLEMING,
General Secretary

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A MOUTH PIPETTE AND CONTAINERS FOR SMALLER ORGANISMS

A BIOLOGIST frequently encounters choice specimens for microscopic study in such materials as plankton, bottom deposits or mixed cultures of protozoa. But because of the time required to separate the desired forms from the mass of debris by the ordinary means at hand the specimens are usually sacrificed. For the same reason mixed cultures of protozoa are often tolerated. In my investigation of the soft parts of the foraminifera, many thousands of individuals ranging in size from 40 to 500 μ were isolated. In

the preparation of stained materials, it was necessary to change reagents without contamination. It was also necessary to avoid loss, or injury to the fragile protoplasmic parts after decalcification. The pipette illustrated (A) has given several years of satisfaction

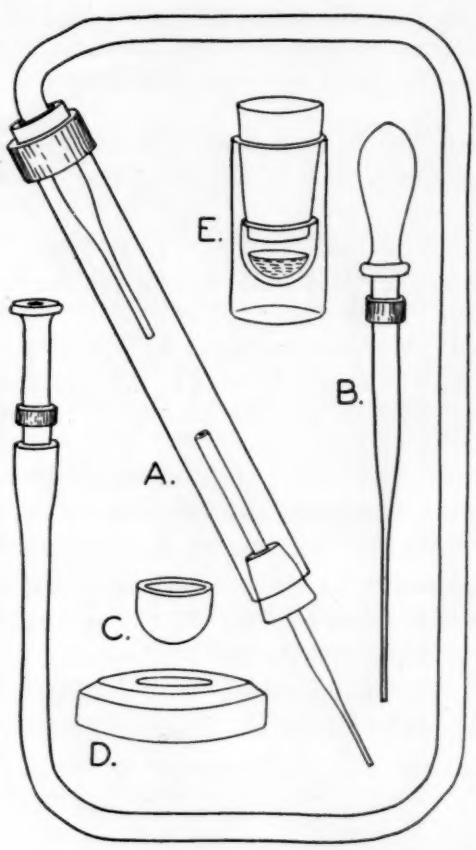

FIG. 1

and is to be recommended for the manipulation of living or fixed organisms of the magnitude mentioned.

The barrel is as convenient in size and weight as that of a fountain pen. Small organisms are drawn into the pipette by capillary attraction controlled by releasing the pressure of the tongue which is held against the end of the mouthpiece. The pipettes require a minimum of material, time and skill to prepare, and can be easily replaced in the barrel. Sterile pipettes of graduated sizes may be conveniently stored in test-tubes. Coating the pipette with paraffin prevents rhizopods and other adhesive organisms from sticking to the walls of the pipette.[1] While changing reagents the barrel constitutes a trap with a capacity of about 8 ml and may be held in any position without contaminating the mouthpiece, or filling the pipette with the contained fluid. By holding the barrel in a vertical position, pipette uppermost, the pipette stopper may be removed and the contents emptied.

At least three holders were necessary in my work. These were marked with bands cut from rubber tubing as follows: white for living material, red for general reagents and black for anhydrous solutions. It is very convenient to mark hand pipettes (B) in the same manner. A rack of suitable height and capacity for the pipette holders, attached to a ring stand or built above the microscope table, is very convenient.

Small or rare organisms were handled to advantage in containers made from the bottoms of bacteriological test-tubes (C) cut with a hot wire and ground flat on top with a carborundum stone. Supports (D) for these containers were made of plaster of Paris similar to the illustration. For storage these containers may be stoppered and placed in shell vials (E) as illustrated. Large or more abundant organisms may be collected in embryological watch glasses.

The following materials are necessary in the construction of the described pipette and holder: 5½ inches of 14 mm glass tubing; 10 inches 7 mm glass tubing; 18 inches ¼ inch rubber tubing; several 00 rubber stoppers; 4 mm thin-walled soft glass tubing is essential for the pipettes.

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[1] Suggested by Dr. Kofoid.

MICROSCOPE LAMP FOR BIOLOGICAL LABORATORIES

THE lighting units used on the students' tables in the elementary botanical laboratories of the Life Sciences Building at the University of California have occasioned so much comment from visiting botanists and zoologists and have brought so many requests for specifications that publication of a brief description of these lamps seems advisable. Besides having proven so completely satisfactory as sources of artificial illumination for microscopic and other laboratory

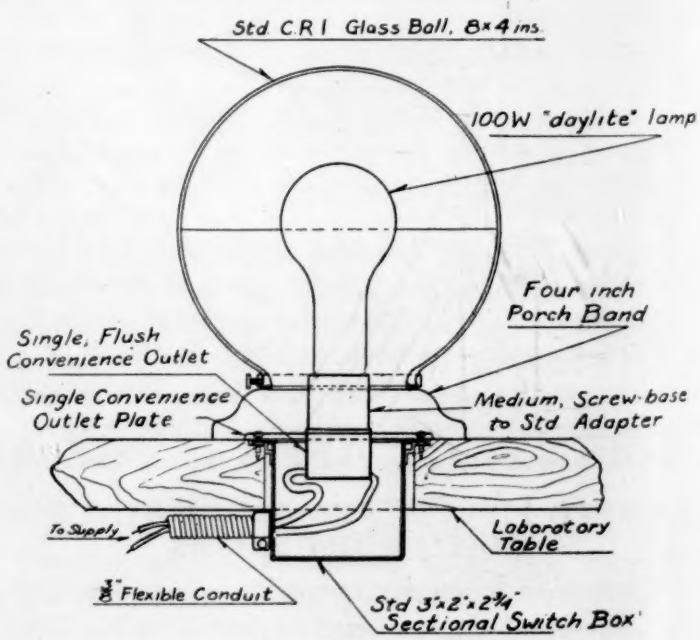

FIG. 1

work, the cost of these lights is only a fraction of that of the table lamps supplied for similar purposes by the optical and laboratory supply companies.

Along the middle line of each of the laboratory tables, which are 9 feet, 10 inches by 42 inches, and 30 inches high, and which are designed to accommodate three students on each side, three such lamps are fixed. For the installation of each lamp the following parts, which can be secured from any jobber of electrical supplies, are needed:

1 Single flush convenience outlet.
1 Single convenience outlet plate.
1 Medium, screw base to standard adapter.
1 Sectional switch box.
1 Four inch porch band.
1 C. R. I. (crystal rough inside) glass ball, 8 x 4 inches.
1 100-watt "daylite" lamp.
2 1-inch round head brass screws.

Connection of the lamps to a wall outlet is through a wire attached to the under surface of the table top; current is supplied to the convenience outlets, which are sunk in holes in the table top.

The total cost of these items per lamp at the time of our installation was slightly less than $2.75. We have found the illumination sufficient for the use of the binocular dissection microscope and for standard compound microscopes for all magnifications up to that supplied by the 2 mm oil immersion objective and ocular 10. If the diffuse illumination coming directly to the user's eyes from the upper part of the lamp proves unpleasant, which in practise it seldom does, the upper part of the ball may be painted on the inside surface with white, opaque paint. If for any reason it is desired to remove the lights so that the table, entirely free from obstructions, may be used for other purposes, it is only necessary to remove the two wood screws from the "porch ring" and slip the adapter with the daylight bulb out of the receptacle.

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SPECIAL ARTICLES

INFECTION IN MICE FOLLOWING INSTILLATION OF VESICULAR STOMATITIS VIRUS

WE have previously stated[1,2] that intracerebral inoculation of anesthetized white mice with the virus of vesicular stomatitis of horses uniformly induces characteristic lesions in the organs of the central nervous system. Recently Webster and Fite[3] have succeeded in transmitting a fatal infection to mice by means of intranasal instillation of louping-ill virus.

Regular transmission to mice of a lethal infection has also followed nasal instillation of the Indiana and New Jersey[4] strains of vesicular stomatitis virus. The cerebral tissue, aseptically removed from mice succumbing to the experimental infection induced by intracerebral injection of the virus, was ground in a sterile mortar with hormone broth of pH 7.5 to a 1:10 suspension and filtered through a Seitz disk, and instilled intranasally in doses of 0.04 cc by means of a tuberculin syringe fitted with a blunt needle. The nasal tissues were not injured.

Within four to six days, the animals developed hyperesthesia, tremors, incoordination, spastic paralysis most marked in the posterior extremities and prostration, followed by death on the fifth to eighth day. The series of nasal infections was carried through twelve passages—in each transfer the brain of nasally infected mice having been used as the inoculum.

The pathological changes are similar to those occurring in guinea-pigs and mice[1,4] inoculated intracerebrally with neurotropic vesicular stomatitis virus. The nerve cells of the hippocampus in the brain and the anterior gray matter of the cord contain typical intranuclear inclusion bodies, such as are found in the epithelial cells of the guinea-pig pad inoculated with the virus of vesicular stomatitis or of foot-and-mouth disease and in the nerve cells of the guinea-pig inoculated intracerebrally with the virus of vesicular stomatitis.

In addition to the effective brain tissue in dilutions as high as 10^7, the virus in the 26th generation of tissue cultures[2] in dilutions of 10^6 and in the filtrates of affected guinea-pig pads was found to be active when instilled nasally in mice. The question arises whether in the field vesicular stomatitis may be conveyed by nasal inhalation of the incitant.

It appears, therefore, that the virus of vesicular stomatitis is strikingly active in a minute quantity (1 to 10 million dilution) in the nasal passages of mice and that the uninjured nasal mucosa is as sensitive to infection as is the injured brain or pads of animals.[5]

These experiments suggest that the closely related

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[5] All operations were done under ether anesthesia.

virus of foot-and-mouth disease may also be infective in high dilution through intranasal inhalation.

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ACTIVE IMMUNIZATION TO ANTHRAX BY MEANS OF HETEROPHILE ANTIGEN

SINCE the work of Forssman[1] showing the existence and action of heterophile antigens and antibodies, subsequent investigations have shown these to be widely distributed in animals and bacteria. Recently, Combiesco, Satamtesco, Nestoresco and Adam have demonstrated this antigen in anthrax bacilli.[2]

The work of Bailey and Shorb,[3] and that of Powell, Jamieson, Bailey and Hyde,[4] indicates that the heterophile antibodies play an important rôle in the protection, treatment and recovery in pneumococcus infections.

Thus the following experiment was done to determine whether or not heterophile antibodies play any rôle in anthrax infections.

Two rabbits were inoculated with boiled sheep corpuscles. After a period of two weeks had elapsed from the last injection, a small amount of blood was removed from the ear vein and a titration made to determine their heterophile antibody content. Then these two rabbits, along with two controls, were given subcutaneous inoculations of a virulent anthrax bacilli. The results are shown in Table 1.

TABLE 1

Previous treatment of rabbits	Heterophile Titer*	Amount of turbid suspension of virulent Anthrax bacilli inoculated	Results
None	none	0.2 cc subcutaneous	Died in 3 days
None	none	0.2 cc subcutaneous	Died in 4 days
5 intraperitoneal injections of 5 cc of 20 per cent. solution of boiled sheep corpuscles.	800 units per cc	0.2 cc subcutaneous	No ill effect. Observed for a month
5 intraperitoneal injections of 5 cc of 20 per cent. solution of boiled sheep corpuscles.	3200 units per cc	0.4 cc subcutaneous	No ill effect. Observed for a month

* Heterophile unit is defined as sufficient antibodies to hemolyze in the presence of complement 0.1 cc of washed erythrocytes diluted 1 plus 3 in terms of whole blood concentration.

From the above experiment it is evident that immunity developed by stimulation with the heterophile antigen in sheep's corpuscles protects rabbits from anthrax infection.

Since heterophile antibodies can be produced by oral administration of the antigen,[5] this method of anthrax immunization might be adaptable to the protection of individuals whose occupation exposes them to anthrax infection. Such individuals as wool sorters and tannery workers might be protected from anthrax infection by oral administration of the heterophile antigen in sheep corpuscles.

The use of heterophile antiserum in the treatment of anthrax infection is being studied, and will be reported later.

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